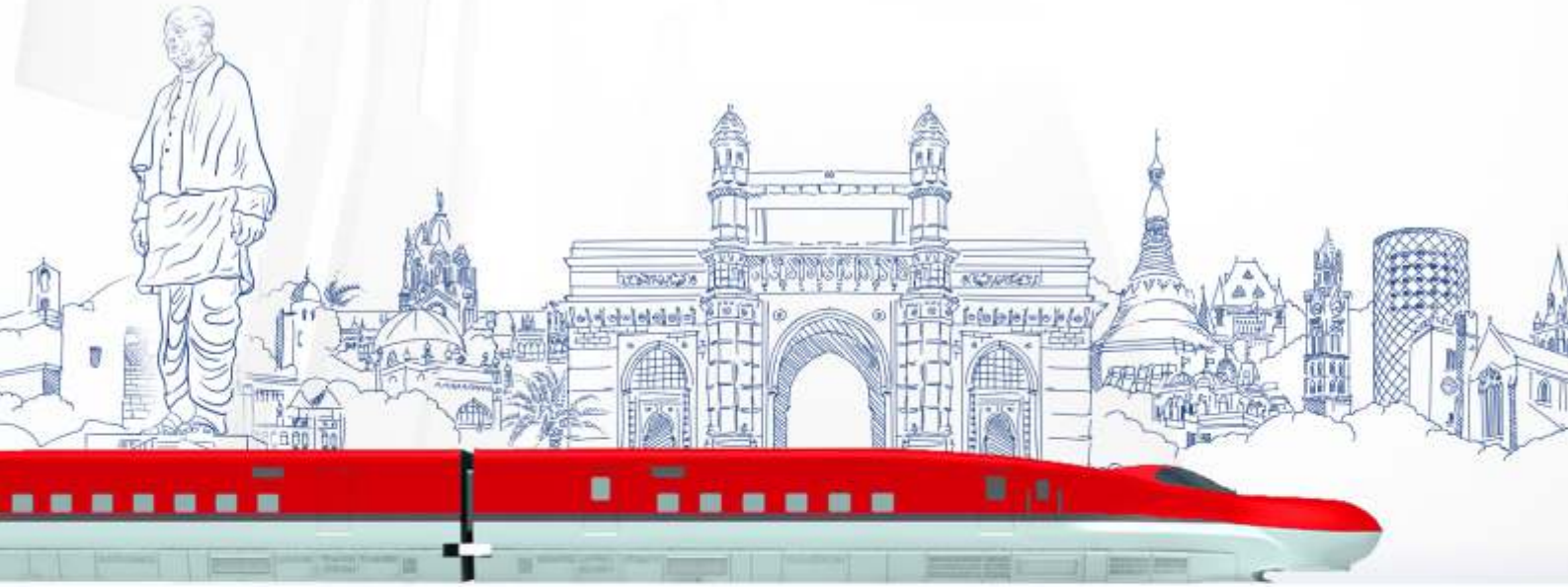
India's Bullet Train Ride

The Journey So Far



NHSRCL

National High Speed Rail Corporation Ltd.

Note to the Reader

A state-of-the-art High-Speed Rail (HSR) system is a giant leap for India in terms of development, as we share space with developed nations on the Global HSR map. This booklet is an attempt at documenting the journey of National High Speed Rail Corporation Limited (NHSRCL) so far with the major feats achieved and the challenges faced along the way. The ride has been full of ups and downs. The document is also an ode to the hard work put in by the team at NHSRCL to help India achieve its dream of a bullet train.

This is a rolling document that will be updated as the project progresses.

Hope you enjoy reading it.

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Chapter 1

INTRODUCTION

As one of the country's most ambitious projects – a High Speed Rail (HSR) corridor connecting India's populous city of Mumbai with Ahmedabad – gathers steam, the country is all set to make a giant leap in terms of development and enter the league of developed nations on the Global HSR map.

Soon, clogged highways, airport delays, and uncomfortable journeys will be a thing of the past. Our very own 'bullet' train, a nickname the train gets from its bullet-like shape and speed, will be seen tearing along west India's landscape, covering the 508 km distance between the two financial hubs in just about two hours. This will be a huge time saving compared to current travel times between the two terminal stations of about nine hours (by bus) or six hours (by conventional railways).

Indian Railways is the fourth largest railways in the world, ferrying a mammoth 8,300 million passengers and over 1,160 million tonnes of freight every year on its massive track network spanning across a distance of about 70,000 km. The HSR project will be a complete game-changer in this landscape and is set to redefine the way we Indians travel.

The state-of-the-art high-speed trains, running on the Japanese Shinkansen technology, will zip at speeds of 320 km/h, which is more than double that of Indian Railways' fastest train – the Gatiman Express that chugs along at 160 km/h, and we as passengers will get to experience one of the best HSR technologies available globally, offering the highest levels of safety, comfort and reliability as we hop aboard this world-class system.

As India takes giant strides on the path to development and positions itself to join the coveted list of global superpowers, a transformation of our 167-year-old railway system is an integral part of this journey. Towards this end, Indian Railways has envisioned a phased upgradation of its network, both passenger and freight.

The National Rail Plan (NRP) for India envisions enhancing the outreach of the HSR system and increasing connectivity to all the cities of importance. As part of the National Infrastructure Pipeline (NIP), seven HSR corridors have been identified for which the work of preparation of Detailed Project Reports (DPRs) has been entrusted to National High Speed Rail Corporation Limited (NHSRCL). These include:

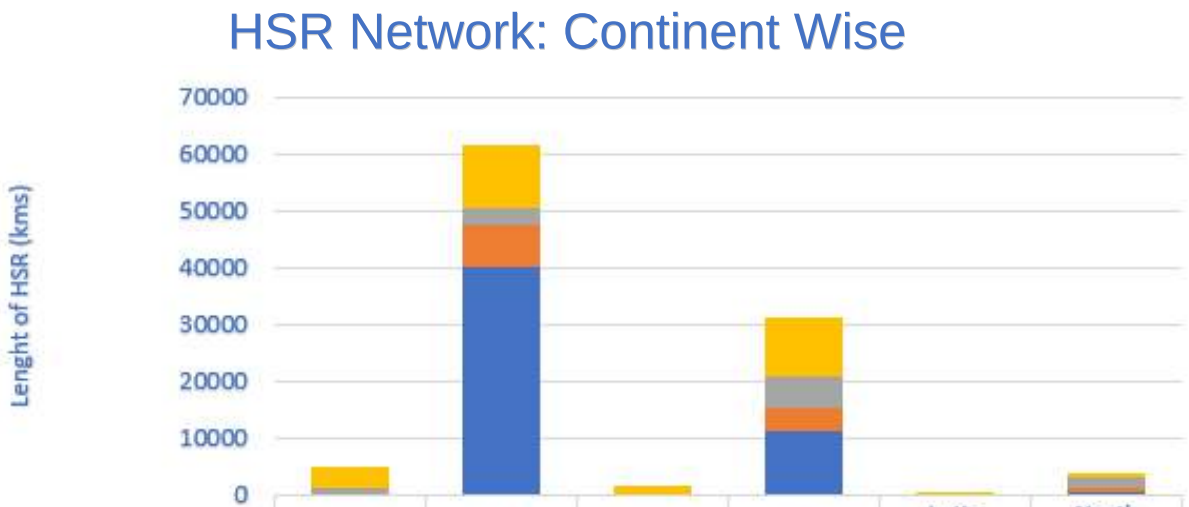
1. Delhi – Lucknow – Varanasi (865 km)
2. Varanasi – Patna – Howrah (760 km)
3. Delhi – Jaipur- Udaipur – Ahmedabad (886 km)
4. Delhi – Chandigarh – Ludhiana - Jalandhar- Amritsar (459 km)
5. Mumbai – Nasik – Nagpur (753 km)
6. Mumbai – Pune - Hyderabad (711 km)
7. Chennai – Bangalore – Mysore (435 km)

Inauguration ceremony of Tokyo-Osaka Shinkansen in 1964

Gatiman Express is the fastest running train in India as on date with a maximum speed of 160 kmph

According to the Union internationale des chemins de fer (UIC), high speed rail combines many different elements which constitute a “whole, integrated system”, infrastructure (new lines designed for speeds above 250 km/h and, in some cases, upgraded existing lines for speeds up to 200 or even 220 km/h), rolling stock (specially-designed train sets), telecommunications, operating conditions and equipment, etc.

Globally, high-speed trains cover a total network of over 52,000 km across Asia Pacific, Europe, Middle East, North America and Africa as on February 27, 2020, according to data compiled by UIC’s Passenger Department. This figure is expected to double (to 1,04,413 km) in the near future with several countries planning to expand their networks and new ones entering the fray.



	Africa	Asia	Australia	Europe	Latin America	North America
Long term Planning	3665	11133	1749	10579	511	949
Planned	1049	3167	0	5508	0	1659
Under Construction	0	7241	0	3956	0	763
In Operation	200	40125	0	11424	0	735

Figure: Continent-Wise break up of HSR networks
Source: UIC (https://uic.org/IMG/pdf/20200227_high_speed_lines_in_the_world.pdf)

Historically, Japan was the first country to make a foray into the HSR space with the Tokaido Shinkansen, which was started between Tokyo and Osaka in time for the 1964 Olympics. The country now has over 3,000 km of high-speed rail lines connecting all its major cities and the lives of whose populace have completely been transformed by the Shinkansen network

In Europe, several countries were building new rail lines after the existing ones were destroyed in the aftermath of World War II. As per UIC records, France was the first country to inaugurate its Trains a Grande Vitesse (TGV) line between Paris and Lyon. Italy followed next with a HSR system between Rome and Florence. Today, Spain, Germany, Belgium, Denmark, Finland, Austria, Britain, Netherlands and Switzerland are all connected via highly efficient HSR systems, which contribute to the European Union’s sustainable mobility objectives.

Closer home in Asia, China has taken to HSR in a big way and boasts of a HSR network spanning across 41,000 km, of which over 35,000 km is already operational (Source: https://uic.org/IMG/pdf/20200227_high_speed_lines_in_the_world.pdf). It is the longest HSR network in the world, which grew from nothing in 2007-10 to covering two-thirds of the national land area of China from 2011-15. The HSR is being used by 1.7 billion passengers every year, according to a report by the World Bank.

Almost all the countries where HSR systems were introduced have reported big gains, to the quality of life of their people, economies and the environment.

Chapter 2

WHY HSR?

We are a society fascinated by speed. From fast cars to zip us around town and same day "express" deliveries of essentials to high-speed internet, fast computing and Elon Musk's futuristic hyperloop, humans are trying to contract time and space in this zealous need for speed.

As concepts of time and distance evolved, the 21st century was marked with innovations by mankind to shrink the coordinates further in a globally connected era. People started moving out of their nuclei in search of a better standard of living and employment opportunities.

In this landscape, high-speed trains have come to symbolise the future of travel in the world over especially for distances from 500 km to 800 km. A 2019 International Energy Agency (IEA) report titled, 'The Future of Rail' revealed that HSR activity worldwide has expanded fivefold in less than 10 years. Despite its limited geographical spread, HSR activity grew by more than 11 per cent per year between 2000 and 2019, nearly three-times faster than growth in any other non-urban transport mode, attaining nearly 1029 billion passenger km in 2019.

Introducing a HSR system will fuel India's economic engine, help meet the environmental and energy challenges of this century and also place the nation on the fast track to development. From a people perspective, high-speed trains are a more easily accessible mode of commute compared to air travel, even as the total journey times are similar when seen from door to door.

Social Gains

A HSR is a high-capacity mode of transport – up to 2,00,000 people can use the system each day reducing congestion on roads and on other modes of travel. It offers people a safe, reliable and comfortable mode of travel increasing productivity as the time and energy spent in commuting delays can be saved.

A HSR system plays a pivotal role in achieving regional integration and creating socio-economically balanced societies. It reduces the temporal distance between cities, taking away the need for people to migrate to big Metropolitan towns or financial hubs to earn a living. Cities that fall on a HSR connection to a big hub become satellite towns, bringing down congestion and the plethora of urban challenges that come with it.

This improves the overall quality of life of people in the region as a whole who can travel with much lesser time and costs. Studies have revealed that with the introduction of HSR, sectors like tourism, healthcare and education get a major boost in the region where the network is introduced.

HSR networks are known for their punctuality and multi-modal connectivity. HSR stations are easy to access as they are mostly located in busy city centres, making them a preferred mode of travel for passengers. However, stations which are located at the outskirts can be converted into transit hubs where the local population can interchange between multiple modes of transport.

The coming up of a HSR line also has an impact on real estate prices and overall development of the cities it touches due to the improved connectivity it brings to the region.

The introduction of a HSR link between Paris and Lyon led to an increase in real estate prices two years before the line was flagged off and then again two years after the train services commenced. The impact was seen the maximum in areas that were located within a 15 minute perimeter of the line.

Station Area Development, which is on the cards for the Indian HSR corridors too, improves the quality of life of people living there and creates city hotspots for locals and tourists alike to visit.

Economic Gains

The new rail services will connect India's economically vital mega-regions and make them more productive, mobile and internationally competitive. Globally, it has been observed that cities that have HSR networks are more developed and flourish. The connectivity offered by the rail link helps attract businesses, skilled workforce and tourists.

According to a study conducted by London School of Economics and Political Science and the University of Hamburg, cities that are connected to HSR systems witnessed a rise in Gross Domestic Product (GDP) by at least 2.7 per cent compared to their neighbours, that were not on the route.

It also revealed a direct correlation between increased market access through HSR connectivity and a rise in GDP. The study cites that for every 1 per cent increase in market access, there is a 0.25 per cent rise in GDP. This research was focussed on the HSR line connecting Cologne and Frankfurt opened in 2002, where trains run at 300 km/h.

The coming up of a massive infrastructure project of this magnitude, in turn, creates employment opportunities for the local population, both during the construction phase and after operations begin. During the construction phase itself, the Mumbai Ahmedabad High Speed Rail (MAHSR) project is expected to create about 90,000 (direct and indirect) jobs.

For a country like India known for its technical prowess, getting a new advanced technology for MAHSR corridor is also going to aid the process of Transfer of Technology and skill development of local manpower. Those working on the project will undergo trainings in Japan and use their upgraded skills to reduce unemployment, raise incomes and improve the overall standard of living of people and communities.

A high-speed connectivity also gives a boost to tourism as people from nearby areas can make comfortable day trips to see city hotspots. The opening of the Paris-Lyon HSR link in France, for instance, resulted in an increase of 144 per cent in passengers travelling for business and leisure.

About 14 million tourists use the TGV Mediterranee to travel to the south of France, according to a report titled 'The Economic Footprint of Railway Transport in Europe' published by ECORYS in October 2014.

The report cites a similar impact in Italy with the opening of the Rome – Milan line, where more than 40 million passengers used the HSR system in the first two years and overall demand

witnessed an increase of 39.1 per cent from 2009 to 2011. There was a shift from air to rail travel – air travel decreased by 1.3 million passengers a year between the cities serviced by high-speed trains.

For the economy as a whole, the demand for machines and materials like cement, steel, etc needed for Construction sees a steep increase offering a boost to these industries. The MAHSR project will generate a requirement for about 7.5 million tonnes of cement, 2.1 million tonnes of steel and 0.14 million tonnes of structural steel, all of which will be made in India.

Environmental Gains

Rail accounts for 8 per cent of the world's motorised passenger movements and 7 per cent of freight transport, but uses only 2 per cent of the world's energy demand.

A HSR system generates one-third the carbon emissions compared to car travel and just one quarter compared to air travel undertaken by the same number of people, taking into account the average loadings typically achieved on each mode.

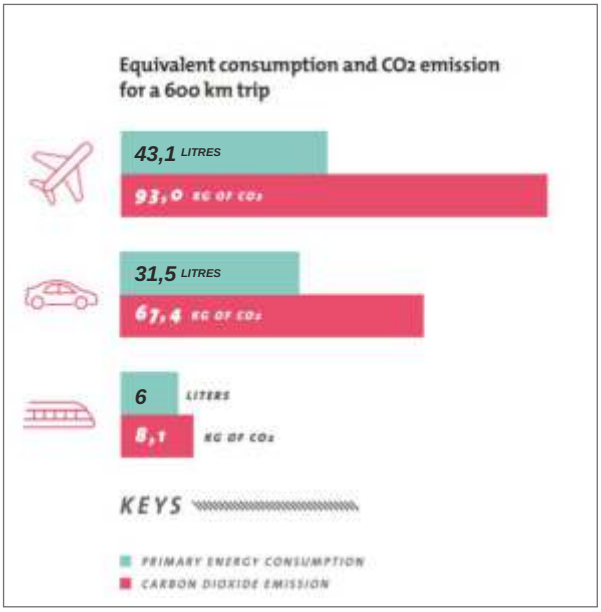
This makes it an eco-friendly mode of travel which will help bring down carbon emissions from the transportation sector as a whole.

OPTIMAL DISTANCE FOR HSR CORRIDOR

A World Bank analysis of China, the biggest HSR market concludes that HSR is the preferred mode of transport for distances ranging between 150 km and 800 km. In countries like Japan, France and Korea, a distance of about 500 km between two major cities that are connected by a corridor with good economic development in the area formed the major attributes for selection.

In addition to the origin and destination stations, the other stations along the route also must be chosen in a manner that while the 'important' cities are covered. Some of the corridors where HSR projects have been very successful meet these parameters. These include Japan's Tokyo – Osaka line (515 km), France's Paris – Lyon line (425 km) and Spain's Madrid – Barcelona line (503 km).

The world over, a shift has been noticed to HSR from other modes of travel such as air and rail, especially for longer distances (over 500 km for air and 500 to 800 km for rail).



Source: https://uic.org/IMG/pdf/uic_high_speed_2018_ph08_web.pdf

According to statistics of UIC, a high-speed train emits just 8.1 kg of CO_2, compared to 93.0 kg by an aeroplane and 67.4 kg by a car for a 600 km trip

In case of India, a HSR system will facilitate a shift of passenger traffic from air and road to the high-speed train running between the cities that start to get serviced. This shift will have a positive impact on the environment as a whole, as it will help reduce greenhouse gas emissions and improve air quality.

Mumbai- Ahmedabad High Speed Rail Corridor

The introduction of a high-speed rail corridor in a country marks the start of a transportation revolution and, therefore, what route is selected for the first line becomes very important.

The Mumbai – Ahmedabad corridor fits all of the above requirements. The corridor connects India's most populous city, Mumbai, with the seventh most populous one and the area between them has seen significant economic growth over the past few decades.

Imagine traversing the 508 km distance between Mumbai and Ahmedabad in all of two hours, as against about nine hours that you presently take by bus or six hours that a conventional Shatabdi Express chugs along in. Sounds unbelievable, doesn't it?

Chapter 3

THE GENESIS OF NHSRCL

The first mention of a HSR for India was made back in 2009, soon after which a pre-feasibility study was initiated for the Mumbai – Ahmedabad corridor. This was followed by similar studies for other HSR corridors.

Such was the buzz created by the news of HSR connectivity in India that several foreign countries evinced interest in the potential HSR corridors and helped prepare feasibility studies.

The seed for the MAHSR corridor, as we see it taking shape today, was sown in 2013, when on a trip to Japan, the then Prime Minister of India agreed for a joint feasibility study to bring the HSR technology to India in collaboration with the Japanese government.

Interestingly, all the technical aspects of this study were handled by the Japanese, who are the global experts in high-speed rail. But, it was termed as a 'joint' study because the funding was shared. In 2014, the joint feasibility study was constituted and a final report was submitted in July 2015 by the Japan International Cooperation Agency (JICA) consultant. This report is what forms the basis for the Mumbai Ahmedabad high-speed project.

Inking of the Deal

The Government of India took a unique initiative – a detailed review of this joint feasibility report by the Committee on Innovative Collaborations under the aegis of Vice Chairman Niti Aayog and Department for Promotion of Industry and Internal Trade. The committee looked into all the fine details of this report, including the reason for selection of the Japanese Shinkansen technology when there are other HSR technologies available the world over.

SHINKANSEN: THE BULLET TRAIN

The Shinkansen system offers one of the highest safety levels in the world – there have been zero passenger casualties from when the first Shinkansen train started in Japan in 1964. They run at average punctuality levels of 40 seconds, which is also impeccable.

In the meantime, the Japanese government gave their financial proposal on funding at concessional rates, which was also examined by the committee. Based on the recommendations of this committee, the Cabinet approved India's first HSR project in December 2015.

The timing of the approval is a story in itself. The Cabinet nod coincided perfectly with the visit of then Japanese Prime Minister Sh Shinzo Abe to India for the India - Japan Summit meeting. The deal was instantly inked with the signing of a Memorandum of Cooperation between the two Prime Ministers, Sh Shinzo Abe and Sh Narendra Modi, on December 12, 2015. The implementation of the MAHSR project was now on track. This became a turning point for India's HSR journey.

India Japan Summit Meeting between
Sh Shinzo Abe, then Prime Minister of Japan,
and Sh Narendra Modi, Prime Minister of India,
on December 12, 2015

One of the modalities agreed upon by the two governments was that a separate company will be established to execute the MAHSR project on the lines of Delhi Metro Rail Corporation Limited (DMRC). On February 12, 2016, under the Companies Act, 2013 with an object to finance, construct, maintain and manage the High Speed Rail Corridor in India, National High Speed Rail Corporation Limited (NHSRCL) was born as a Special Purpose Vehicle (SPV) with the partnership of Government of India (through the Ministry of Railways), Government of Gujarat and Government of Maharashtra.

With three part time Directors pulled in from the railways, its prime goal was to collaborate with the Japanese partners and immediately take up the MAHSR project.

Action Activation

NHSRCL, though born, had no resources of its own and had to rely on Indian railways officials to manage affairs and come up with schedules and procedures.

Amidst all the excitement of bringing a new technology to the country, a lot of work needed to be done before the project could actually take off on ground. A HSR project like this was a first for India and experts in the country had no experience, existing documents or technical specifications to carry out construction and operations of such a system.

The Japanese and Indian sides agreed to not waste any more time and immediately embarked on a follow up study, which would detail the project further. In addition to the follow up study, they also had to start working on the basic designs, detailed designs and Schedule of Dimensions because this is what the project would ultimately be executed with.

BOARD OF DIRECTORS

The present strength of Board of Directors of the Company is nine, comprising five functional directors viz. the Managing Director, Director Projects, Director Finance, Director Rolling Stock, and Director Electrical and Systems; and three part-time official directors nominated by Government of India including Chairman and one official director nominated by Government of Gujarat.

Interestingly, everything moved so fast that the Indian government had still not allocated funds for the new project through the budget. So, the follow up study was funded by Japan. Another challenge faced was that the loan from Japan could only get sanctioned after social impact assessment and environment assessment was done. But the preparation of designs could not be delayed. The Japanese government agreed to give a grant for the execution of design work through a consultancy in December 2016. This was called General Consultancy excluding supervision.

The very first contract of NHSRCL was awarded to Rail India Technical and Economic Service (RITES) to carry out a detailed survey in October 2016. This marked the transition of the project from a desk study to execution, which entailed surveys, geotechnical investigation and then developing social impact assessment.

Building Team NHSRCL

While the processes were being streamlined and work on the HSR line was being initiated full-throttle, NHSRCL needed an able leader to steer the organisation to greater heights. This person would also be the Indian face for discussions with the Japanese counterparts.

Sh Achal Khare, who was working as Executive Director, Infra Civil in Railway Board, was deeply involved with the NHSRCL at the time. As convenor for 14-15 key items, including SODs, bridges, stations, etc, which formed part of the technical aspects that needed discussion with the Japanese, he represented the Indian side for the HSR project.

In September 2016, Sh Khare was promoted as Advisor Infra and the entire HSR project came under his purview. At that time, NHSRCL did not have any regular Director, so he was given the title of 'Coordinating Director'. On April 20, 2017, Sh Khare became the first Managing Director of NHSRCL, and also the first regular employee.

NHSRCL started working from a tiny make shift office with four employees on deputation from railways. This core team discussed all matters related to the project and were all wearing multiple hats in this new set-up. They were aided by a Japanese team, who helped NHSRCL through the initial designs and processes.

With the organisation growing in size, the tiny space that NHSRCL occupied was no longer sufficient. This prompted a hunt for a new office, which ended at Asian Institute of Transport Development, Asia Bhawan in Dwarka, a modern, roomy office space with sprawling lawns that offered NHSRCL an independent floor. The set-up also had facilities like an auditorium, large conference rooms and dining areas.

Its Dwarka location made it affordable compared to other commercial spaces that were under consideration in central Delhi. Connectivity to Delhi Metro was an added bonus as even Railway Board was just 30 minutes away. In June 2017, DMRC was given the challenging task of furnishing the entire office in just 45 days. And as planned, NHSRCL moved into the new office on August 14, 2017.

Between November 2017 and 2018, functional Directors with deep knowledge of railway functioning and expertise were appointed for key roles. Sh Rajender Prasad, Director Project, was the first to join on November 29, 2017 and was given the responsibility to look after the work of preparation and finalizing the civil contracts.

Sh AK Bijalwan, was the next to join on January 2, 2018 as Director, Finance and was tasked with looking after the JICA loan, structuring the land acquisition compensation and hiring the right talent. Sh Vijay Kumar, who was already working with NHSRCL as Executive Director, Rolling Stock took over as Director, Rolling Stock on August 23, 2018 to plan for trains and depots. Sh Sandeep Kumar joined on August 31, 2018 as Director, Electrical and Systems and looked into utility diversion, telecom and signaling works.

Slowly, more specialists joined the team and the different departments, as we see them today, started taking shape. Today, NHSRCL is a 250-employee strong organisation, comprised of some of the best technical minds of the country.

THE GROUND BREAKING CEREMONY

By 2017, there had been enough talk about the HSR project coming to the country and everyone wanted to see something happening on ground. Soon, NHSRCL was told that there needs to be a 'ground breaking ceremony' for the MAHSR corridor. The demand was for a site where something needs to be physically done for the bullet train project, and not just a symbolic start.

Getting started on the main rail line was not possible yet, as NHSRCL was still working out the modalities of land acquisition. So, a decision was taken to plan a 'ground breaking ceremony' for the High Speed Rail Training Institute. In flat four months, the core team worked day and night to ready itself for the ground breaking ceremony, which was being planned for September, 2017.

It was later realised that without a detailed design at hand for the training institute, constructing a building would have been impossible. So, NHSRCL decided to organise a 'ground breaking ceremony' for a sample training slab track instead. For the site, several options were considered, and a site at Gandhinagar was selected as it was clear and located right next to Indian Railways, making it easily accessible.

Elated with their identification of suitable option, when NHSRCL officials went to the government with the site selection, it was rejected on grounds that "Gandhinagar had no link with high-speed." The next suggestion – Sabarmati Yard – where land was available even though it was not clear, was also shown the red.

Time was running out and tenders had to be floated and a site had to be finalised soon. Then, Vadodara was suggested and NHSRCL team rushed to the vibrant city and selected the present option at National Academy of Indian Railways (NAIR) after evaluating many others.

On September 14, 2017, a 'ground breaking ceremony' for MAHSR corridor at Sabarmati and the start of physical construction at Vadodara for training slab track was held with the who's who of India and a 10-employee strong NHSRCL team.

MAHSR Ground Breaking Ceremony held on September 14, 2017

A VISUAL IDENTITY FOR NHSRCL

A lot of thought went into designing the blue and red logo that NHSRCL is known by today. Its design symbolises the core elements of the high-speed train network that the organisation is known for – speed, technology and connectivity.

NHSRCL
National High Speed Rail Corporation Ltd.

Figure: NHSRCL Logo

The blue element is a graphical representation of a running 'cheetah', which is the fastest animal on the planet. The red element is shaped like an outline of a bullet train, a reflection of the fast speed at which these trains run. The red of the train silhouette is a sneak-peek into the colour of India's bullet train, which will be red too! The 3 grey dots stand for interconnectivity of this system with other modes of transportation, both existing and upcoming.

When the logo was being conceived, an important facet was youth appeal. A decision was taken to hold an open competition among students of India's top design institutes, including National Institute of Design (NID) and School of Planning and Architecture (SPA). The response was overwhelming.

To select the final design, a three-member committee headed by eminent painter and architect Sh Satish Gujral was formed, which also had members from Niti Aayog and NHSRCL. On October 24, 2017, the design submitted by Sh Chakradhar Aalla, a second-year student of NID was adjudged the winning entry and NHSRCL found its logo.

MAHSR Alignment

Chapter 4

MAHSR CORRIDOR – A LEAP FORWARD

Spanning across 508.09 kilometres, the MAHSR corridor will offer fast connectivity between the two financial hubs located in the states of Maharashtra and Gujarat in western India.

After starting from Mumbai's Bandra Kurla Complex (BKC) area, the high-speed train running at a speed of 320 km/h is all set to revolutionise intercity travel in the region. It will have stops at 10 cities in between namely Thane, Virar, Boisar, Vapi, Bilimora, Surat, Bharuch, Vadodara, Anand, Ahmedabad and will terminate at Sabarmati.

The entire journey will be completed in about 2.07 hours with limited stops (at Surat, Vadodara and Ahmedabad), a fraction of the time taken by conventional trains or road journeys. While most of the corridor will be constructed over ground (463 km is on viaduct), there will be a mixed-bag of tunnels (26 km), bridges (9 km) and embankments (13 km) along the entire journey.

As per current estimates, the corridor is expected to be used by 17,900 passengers every day in each direction, who will be ferried in 35 daily train trips made by 10 car configurations with 24 rakes on the year of commissioning. Train services will operate from 6 am to midnight at intervals of 30 minutes. More trains will be made operational during peak traffic hours, when the time between two trains will be reduced to 20 minutes. This will ensure that maximum number of people can use the services.

These estimates are based on a feasibility study prepared for the corridor, keeping in view a 30-year projection of passenger traffic. By 2053, about 92,900 passengers are expected to use the MAHSR system per day and all the systems are being designed to cater to these future levels of traffic.

With trains running at such high speeds, and handling such heavy traffic volumes, one of the best global technologies in HSR – the Japanese Shinkansen technology – has been selected for the MAHSR corridor after much deliberation.

"For the first time in India, technologies like LiDAR, construction of an undersea tunnel and use of Static Refraction Topography, aerodynamically designed high-speed trains, improved bogies technologies for noise mitigation for maximum passenger comfort, special lurch control system and air tight car body system, Continuous Automatic Train Control (DS-ATC) system for improving track to train transmission, fall-back system, and disaster management systems among other are being brought together under one umbrella for the successful execution of a railway project. Rightly so, by introducing these technologies, India is not only taking the next step towards modernisation of its transport system but has also begun to bring to fruition it's long lasting dream of High Speed Rail."

Sh Achal Khare
MANAGING DIRECTOR

Facilities onboard Shinkansen Trains in Japan

Passenger Information Display System

User-friendly toilets

Modern washrooms

Comfortable seats

WHEELS OF **CHANGE**

The experience of travelling on the new HSR trains will be nothing like what we are used to. Running at superfast speeds of about 320 km/h, they will reach you to your destination in a fraction of the time taken by conventional Indian Railways trains (the present top speed is 160 km/h), on the way ensuring utmost passenger comfort and the highest levels of safety. It is four times the speed of Metro trains.

High-speed trains on the Mumbai-Ahmedabad line will have three classes defined by the configuration of seats – standard class (3 X 2 seats), business class (2 X 2 seats) and grand class (2 X 1 seats).

The trains for the MAHSR corridor are being brought in from Japan and are known for their comfort and reliability. The components used in the trains are highly specialised and are currently not available in the country. But, subsequently, six of the first 24 trains will be partially assembled in India. Each train with a 255 m length will comprise of 10 cars.

> *"Suitable changes were made in technical specifications of the Shinkansen rolling stock to suit them to Indian conditions. My team did a splendid job and took great effort in convincing the Japanese experts for this."*
>
> **Sh Vijay Kumar**
> **DIRECTOR, ROLLING STOCK**

Some **salient features** of these trains are:

Passenger comfort

High-speed trains are going to be used for long-distance journeys, making comfort a very important factor. The higher the speed of the train, the more the vibrations which ultimately result in riding discomfort. The challenge, therefore, is to increase speeds while maintaining the same levels of comfort as on low speeds.

Shinkansen trains have an evolved suspension and damping system to control vibrations. In addition, these trains have a Vibration Prevention Control System, an advanced feature which continuously monitors the level of lateral vibrations and automatically initiates counter measures when these levels exceed limits

Noise and air pressure

The complete train car is designed to contain the levels of noise inside it. The body is made of a hollow double skin structure which does not allow sound to come from outside. Since a majority of noise is generated from the bottom of the train, the floor is fitted with noise absorbent materials to prevent it from reaching the passengers.

When the train enters and exits tunnels, people feel discomfort in the ears because of air pressure fluctuations. For this, the train car is made air tight. Shinkansen trains also have a process of positive air pressurisation inside the train so that sufficient air tightness remains even in the event of a slight leakage.

Designed for a comfortable ride

To ensure that long-distance rides are not a strain, the trains will have a 3 X 2 seating arrangement with extra legroom (1,040 mm) than what we have in present trains (990 mm) and is also much higher than airplanes. The seats are rotatable ensuring that you always face the direction of travel.

Every car has overhead baggage racks and business class compartments have an additional space for baggage, which can be used exclusively for luggage. There is no worry to go offline as the trains will offer Wi-Fi connectivity to keep you connected and catch up on work while you travel. Every train is fitted with an LCD display showing information such as next station, journey time, the current speed of the train with a corresponding audio announcement system.

THE TALE OF THE FANCY TOILETS

Since the trains running on the MAHSR line are made in Japan, the toilets fitted into them are also going to be completely world-class with button actuated toilet seats that have a washing, drying and heating function. The flush will be air plus water type, as seen in aeroplanes. The waste generated will not be strewn on the tracks. It will be stored in massive discharge tanks and emptied out when the train reaches the maintenance depot. There are some challenges around this. The discharge tanks have limitations and Indians are known for drinking large amounts of water! So detailed calculations were done to assess the number of trips each train will make before the discharge tanks get full and it needs to be taken to the depot for cleaning. The toilets will have display tutorials on how to use these special toilets.

Fancy toilets onboard Shinkansen trains in Japan

Utmost passenger safety

Zero fatality rates is one of the USPs of the Japanese Shinkansen system. The trains are embedded with Digital Shinkansen - Automatic Train Control (DS-ATC) system with a special braking mechanism to prevent collision and overrunning at stations. The acceleration is all manual, but if the driver fails to apply the brakes in time, the system takes over and stops the train.

There is no signalling system on the side of the tracks. In DS-ATC, the signalling comes inside the driver's cab which also shows the speed of the train and the permissible limit. In the event that the driver fails to control it, a collision avoidance system takes over to slow the train down.

"Trains are fitted with CCTV cameras and an emergency intercom to facilitate communication between the driver and passengers in case of any emergency. The face of the person calling is recognised and saved to prevent misuse of the system."

Sh Vijay Kumar
DIRECTOR, ROLLING STOCK

Long nose for improved aerodynamics

When you run a train at such high speeds, there is air resistance. The long nose limits air drag, an aerodynamic force that opposes the motion of any object against the air. Most of which comes from the front of the train which clashes against the air with force as the train is running on high speed.

When trains enter tunnels, a lot of micro-pressure air pockets are generated which are released when trains exit the tunnels. This produces a sonic booming sound. This design helps reduce that.

Safe against natural disasters

The train system for MAHSR corridor is embedded with power failure detection brakes, where in as soon as the primary waves of an earthquake are detected, the power supply to the train is stopped and the train stops on emergency braking.

A severe earthquake brings a high chance of derailment when the train speed is higher than 300 km/h. To safeguard against that, there is an automatic system in place which brings the train to a halt within 80 seconds, a distance of within 4 km using special brakes that are fitted in the train.

High speed rail will be fitted with a network of sensors monitoring rail track temperature, rain monitoring (with special sensors in heavy rainfall prone areas) and anemometers for wind monitoring. Crosswind speeds above 30 m/s will send an alarm signal to operational control center in Sabarmati, so the train will be stopped.

WHY DO BULLET TRAINS HAVE A LONG NOSE?

The trains which will run on the MAHSR corridor will be based on the E5 series rolling stock of Shinkansen. In Japan, a lot of effort went into designing the nose of the train which is shaped like a Duckbill's beak.

The long nose allows for better aerodynamics, which allows the train to operate at very high speeds with minimal resistance or air drag. Japanese experts conducted a series of tests which proved that this shape was most effective in reducing generation of pressure waves when trains running at high speeds entered tunnels.

Figure: The nose of Shinkansen E5 (above) as compared to the beak of a Duckbill Platypus (below)

Ahmedabad HSR Station facade inspired by Syed Siddque Jali

Graphic Representation of Station Interiors

Maintenance

To ensure that a clean train greets you at the station each time to make your journey safe and comfortable, a lot goes on at the backend. Each train running on the network is taken to the depot for cleaning on a daily basis, where the passenger areas are deep cleaned for the next trip.

In addition, trains will be put through primary maintenance every alternate day as part of which all the safety aspects of the train are checked to make sure the running is safe and smooth. In addition, there is a monthly inspection, a bogie inspection every one and a half years, where the bogie is dismantled and checked for safety.

"These high-speed trains will not have any droppage on the tracks along the way. The sewage and waste generated on the train, in the toilets and otherwise, will be stored in large waste retention tanks that will be emptied out when the train goes to the depot each day."

Sh Vijay Kumar

DIRECTOR, ROLLING STOCK

DOCTOR TRAIN

What is common between Dr Yellow of Japan and Dr Avril of Spain? They are not MBBS doctors, but the nicknames of special high-speed inspection trains which have special equipment on board to check the health of train system such as the track, overhead wires and other vital installations.

NHSRCL plans to acquire a General Inspection Train (GIT) for the MAHSR corridor which will run at a speed of 320 km/h and will be equipped with the machinery and equipment to check track systems, overhead power supply systems, signalling and communication infrastructure.

GATEWAYS TO **THE FUTURE**

To breathe life into the buildings that will form the HSR station, the design of each of the 12 stations on the MAHSR line will reflect the spirit of the city it is coming up in. This will bring about an instant connection with the local populace, and promote a sense of ownership of the high-speed system.

From an architectural point of view, it is simple to make a modern-looking structure. But, to establish a connect with the local environment, the idea was to pick some elements of the city that locals are proud of and then build the concept on those elements. The stations are conceived as a gateway to a modern way of living.

The HSR station buildings will be modern, with use of materials like translucent glass, but with some reflection of the city to make people relate to them. For instance, Surat is known as the diamond city, so the HSR station building has the diamond shape in the elevation and ceilings.

The Sabarmati station is inspired by the river Sabarmati, and the elevation has waves to represent water. The spikes of the Ashoka chakra will also be seen in the design. Sabarmati hub will have a reflection of the Dandi March that it is famous for.

Ahmedabad architecture is famous for Syed Siddique's iconic jali, which represents the tree of life. The jaali is being recreated in the façade of the Ahmedabad HSR station building.

The plan is to put up an information board at each such HSR station talking about the story behind its concept and how it was developed into its design.

The inside of the station area has an intuitive design, where passengers are guided towards the platform and all functions, such as security, ticketing, etc happen during the course of this movement.

A uniform style has been maintained at all the stations to ensure that passengers using the system get exactly the same feel at all stations.

All the stations will meet international standards in functionality and operations and will have soothing colours and all basic amenities like signages, seating arrangements in waiting areas, lounges, kiosks, etc. Effort has been made to keep the location of the stations inside the limits of the cities, and connected to other modes of transport like railways, city buses, Metro lines, and parking facilities, etc.

High-speed trains will see longer travel times so care has been taken to provide good restrooms, next to which will be nurseries for children. The stations will also have lockers to store baggage for those doing day trip to cities, which a high-speed train system will offer. The stations will also have business lounges for first class passengers.

The stations will have an inclusive design for differently-abled passengers. A wheelchair-friendly design, lowered ticketing counters with braille instructions, tiles on the floor for guidance, dedicated washrooms, braille buttons inside elevators are some of the features.

THANE HSR STATION

The land site identified for the Thane station was infringing upon the mangroves of the west. As a result, the building that houses the platform at the HSR station coming up at Thane had to be disconnected from the main building.

The environmental guideline prescribes that the passengers cannot get down in the middle of the mangroves. Since the route of the train line couldn't be altered, a unique arrangement was formulated.

Passengers disembarking from the train at Thane will have to walk along a passage created underneath the viaduct, which will take them from the platform to Thane Station passenger building, also called the Station Entrance Building (SEB), which is being constructed just outside the restricted area.

Located at a distance of about 600 metres, the SEB will contain all the passenger facilities, such as ticketing, security, toilets, parking, drop off bays and integration with other modes of transportation.

THE UNDERGROUND STATION AT BKC

The underground HSR station coming up in the heart of Mumbai, at BKC, will be a world-class site. International Financial Services Centre (IFSC) building is coming right on top of underground station.

The height of the IFSC building is 90 m, for which the columns inside the station have to be of double the width to bear the load. As a result, the station itself will be very compact with just the minimum facilities that are required as per the HSR. The structural design has been verified by IIT-Mumbai. It is first time in India that such a high rise building will be housed on top of station.

The location is very central – it is at the cusp of Mumbai's busy central and western lines, offering connectivity to the airport as well as the local Metro line. Several elements are being embedded in its design to make the Multi-Modal Integration seamless. It is also proposed that a long subway will connect the HSR station to the airport Metro line, with shops on both sides and carts to ferry older people. Also in the pipeline is a proposal for connectivity with the elevated metro station.

Station area development

Each of the HSR stations are being envisaged to be destinations in themselves. To harness the true potential of improved connectivity with the construction of a high-speed connection, the areas around the stations will be designed as hubs. The idea is to promote existing industries in the city and its surroundings and also build new industrial centres so as to improve the overall standard of living of the local community.

For this, NHSRCL is liaising with various stakeholders including National government, State governments and the local authorities, and two stations each in Gujarat and Maharashtra will be developed by Japanese experts as model stations. These are Virar and Thane stations in Maharashtra and Sabarmati and Surat stations in Gujarat.

To aid this process of economic and social development along the MAHSR corridor through a process of Transit Oriented Development (TOD) around the HSR stations, a Station Area Development Executive Committee (SADEC) has been formed. The committee has representatives from State governments, NITI Aayog, Ministry of Railways, Ministry of Housing and Urban Affairs, NHSRCL along with experts from Japan's JICA, MLIT, JR East and Urban Renaissance.

Green stations

All the HSR station buildings are coming up as 'green' buildings. This means that they will have elements of sustainability featured right in the design, that includes water efficient fixtures, green-pro products for construction, energy efficient light fittings, and multimodal integration with other transport modes, both existing and proposed.

PLATFORM TICKET: TO BE OR NOT TO BE

Indian Railways has a concept of a platform ticket which allows people without valid train tickets to access the platforms, and even the trains. It is almost customary for families to drop off those taking inter-state journeys and drop them off right up to their seats on the train. But, this may not be a feasible option in HSR stations. So, the design teams were posed with a peculiar query – to what extent will people coming to see off their family/ friends be allowed into the station? The team is working on this!

Passive energy-saving measures and active ecological energy will be incorporated in the designs to help reduce the energy consumption of the buildings. All the HSR stations will be equipped with and oriented to benefit from the ecological sustainability of the station buildings.

Where ever feasible, integrated solar panels are being provided in the roof to minimise energy consumption. Elements such as big windows to allow natural light in addition to a view of the outside and proper ventilation will further bring down energy bills. Rainwater harvesting and water rejuvenation pits will be a vital design element for all buildings constructed as part of the MAHSR corridor.

DEVISING THE **HIGH-SPEED** TRACK

For smooth journeys at high speeds, having the right track system is as important as the trains. The MAHSR corridor will work on a ballastless track structure, unlike Indian Railways that runs on the established ballasted track system. The MAHSR line will be built on a frame-type J-slab to economise concrete consumption.The track slab comprises of a pre-cast Reinforced Concrete slab over which fastening

"This process of track laying will be a first for India, and engineers and supervisors working on this process for the MAHSR line will undergo special training and will be certified by Japan Railway Technical Services (JARTS) before they are allowed to work on the sites. The process of laying the tracks is completely mechanised and requires special machinery. This will help achieve economy in the overall cost of the project and the transfer of technology will be beneficial for India in the long run."

Sh Rajendra Prasad
DIRECTOR, PROJECT

Training Track at High Speed Rail Training Institute, Vadodara

devices and rails are fitted. The pre-cast slabs are either 5 metre long or 4 metre long and are fitted with Type 8 fastening systems. At the bottom there is track bed concrete of about 300 mm and circular anchors to hold the precast slabs at regular intervals of 5 metres each.

The track slab is 2,200 mm wide, 4,900 mm long and 190 mm thick, and each slab weighs about 3.9 tonnes. It is laid over the track bed concrete, and a vertical gap of about 50 mm is created between them which is filled by pouring Cement Asphalt Mortar (CAM), a special material which is not used in India so far, in synthetic bags which are especially designed for this. This is used to ensure that there are no gaps left in between and to provide greater elasticity. Special rubber pads will also be placed underneath the rails to provide elasticity and also to absorb vibrations from the high-speed train running.

Further, the cement and sand used to create the CAM needs to be of very high quality. Japanese experts, along with representatives from NHSRCL, took samples from India. After stringent testing, a decision was made to modify these materials and manufacture the CAM locally. While the cement and sand will be procured locally, the special polymer used for the CAM will come from Japan.

The rails will be imported from Japan and JIS Rail 60 kg will be used on the line. These rails have an inclination of 1 in 40 as against Indian standards, where an inclination of 1 in 20 is used. The same inclination is there in the rolling stock wheels. Unlike in conventional railways, the crossings used in the HSR line will be a movable nose crossings to allow for higher speeds – these will also be procured from Japan

Steel bridges

The MAHSR corridor is largely elevated and will go over National Highways, Dedicated Freight Corridor (DFC) tracks, Indian Railways lines and rivers at several locations along the way. The elevated bridge structure on which the train runs, called a viaduct, will be made with concrete. But, where the span between two pillars is more than 60 metres, steel structures will replace concrete girders.

In all, about 28 such steel bridges have been planned along the length of the corridor of spans varying between 60 metres and 130 metres. Altogether, the collective length of these steel bridges will be more than 1 km and about 70,000 tonnes of steel will be used in their fabrication.

Earlier, the idea was to assign contracts for the steel superstructures to Japan Lead (JV) companies as the standards were stringent and the quality levels expected were very high. In March 2019, a high-powered committee headed by Director Project in Indian side and experts from Japan universities and JRTT from Japanese side was formed to evaluate a 'Make in India' possibility here.

"This opening of steel fabrication to Indian players will give a boost to the Indian steel industry and reduce the costs. When Indian players upgrade their standards, they can manufacture for other countries and offer high-quality, cost-effective and reliable products on the global map."

Sh Rajendra Prasad
DIRECTOR, PROJECT

The committee observed that the Shinkansen steel bridges were superior to railway bridges made in our country, but with some guidance and skill development from Japanese experts, Indian companies would be able to deliver the same standards.

PILLARS OF **STRENGTH**

The viaduct structures on which the HSR trains will run have to be designed for high-speed to reduce vibrations that cause noise as well as passenger discomfort. The structures need to be made heavy by increasing their concrete mass, so as to reduce levels of vibrations, increasing the depth of the girders. HSR structures are generally 68 per cent heavier than Metro elevated super structures.

The other concern with structure is to control lateral deflections in order to prevent derailments of moving trains in the event of an earthquake, as the train moves 4-5 km even after the automatic brakes are applied when an earthquake is detected by seismometers.

The viaduct will have noise barriers all along the corridor. The panels will be opaque, and the top is kept transparent so that the running train is visible running on the viaduct. In addition to the tracks, the viaduct will have walkways on both sides for maintenance staff, under which all the installations for Signalling and Telecommunications will be accommodated.

Full-span launching

In a unique launching method, which is being used for the first time in India, the girders forming the viaduct will be cast in a casting yard and then moved to their position on top of the newly-constructed superstructure using special carriers.

Each 40 m girder, with a height of 3 m and weighing 1,100 tonnes, will be lifted by a special launcher and placed on the viaduct. The girder will move along the superstructure till it reaches the location where it will finally be placed.

"NHSRCL has standardised the designs for the structures and foundations, even before the contractors are in place. The contractor has various options to choose from such as 30m/ 35m/ 40m long girders and open or pile foundations to meet the design and quality standards and only has to choose out of these. This will help saving time too."

Sh Rajendra Prasad
DIRECTOR, PROJECT

There will be just one casting yard for every 15-16 km stretch, which means that the last girder that is lifted onto the viaduct will travel 16 km on the superstructure and then be fixed in its final position. At the point, the structure will weigh about 2,500 tonnes.

This has been done because the land available for construction of the MAHSR corridor is very limited. The contractors will have to plan properly to efficiently utilise the available on-ground space. This method also speeds up the construction process.

Every bolt which is put in the viaduct comes with a rubber washer. This is to reduce the impact of vibrations on these parts, which can lead to early wear and tear and breakage.

Another unique construction technique which will be seen in India for the first time is **'Shinzo Piles'**. These are used in areas where the alignment runs next to Indian Railways tracks, where the foundations cannot be very wide and where heavy machinery cannot be taken. In total, more than 100 Shinzo Piles are expected to be constructed along the corridor, each with a depth of 15-18 metres and a diameter of 6-12 metres.

"Preparing bid documents for the civil works for such a mega project was a mammoth task, as HSR structures were new for everyone. All bid documents were prepared from scratch as no template was available. Some unique ideas were conceptualised. Design for all structures on which 'Shinkansen' was riding were finalised and standardized, however other ancillary structures such as architectures, roof of stations, depot structures were left for the contractor to develop, thus originated the concept of 'Standard design' and 'Basic design'."

Sh Rajendra Prasad
DIRECTOR, PROJECT

POWERING THE FUTURE

On the MAHSR Corridor, to meet the energy requirements of the trains, as well as various installations/equipment in several buildings like station buildings, Operation Control Centre, Depots, Training Institute and installations/equipment along the line, a network of 12 traction substations, 2 depot traction substations and 16 distribution substations will be built along the 508 km stretch. Electrical power supply will be used to feed energy for traction (running of trains) and non-traction loads such as depot facilities, signalling and telecom systems, station infrastructure facilities, wayside infrastructure and facilities along the viaduct.

The power supply arrangement has three major components, the power sourcing arrangements which are built through and in consultation with the power Utilities and the "railway side", traction power supply network and, Distribution System Network for non-traction loads.

The power sourcing works require assessment of traction and non-traction loads, identification of suitable location for substations and thereafter through joint survey with power utilities and load flow studies the suitable source of power supply – Grid Substations – are identified. In other Railway projects, these activities are carried out after the electrical contractor and rolling stock contractor are in place and basic designs are available.

This leads to delays in transmission line and GSS augmentation works. NHSRCL has been proactive in assessing the traction power supply needs of the MAHSR project through simulation studies and thereafter carrying out the joint surveys promptly by early 2018, approval of connectivity applications from Utilities were already received. Works of transmission lines and GSS augmentation have started well in time. As the locations of substations, required along the alignment were finalised, land was acquired accordingly.

Almost the entire Traction supply system, Distribution system and the power sourcing arrangements would be "Make in India". This was agreed by the Japanese consultants after several discussions and joint visits to India.

Overhead equipment (OHE) for high-speed

Moving trains derive power from an Overhead Electrification (OHE), which transfers 25KV traction power from a stationary traction supply system to the rolling stock through a pantograph installed on the trains. The OHE comprises of a feeding contact line, overhead wires and supporting arrangements such as cantilevers, insulators and tensioning devices.

For the MAHSR corridor, the OHE system will be similar to the one used in Japanese Shinkansen lines, suitable upto maximum speeds of 320 km/h for the main line. An automatic switched neutral section would be provided, so that there is no need for the driver of the train to operate train mounted circuit breakers while the train moves between two different kinds of power supplies. Thus, eliminating driver fatigue, potential manual errors.

Best practices in energy efficiency

Various energy efficiency and conservation initiatives, best practices have been included in MAHSR specifications which would result in energy savings, better environment quality, financial security and higher savings at stations, depots, OCC and utility buildings.

These include features such as Smart Energy Metering System, Variable Refrigerant Flow System, Heat Recovery Systems, Variable Frequency Drives in various equipments, Lighting Control System etc. Apart from above, various guidelines of Energy Conservation Building Code and National Building Code related to comfort, lighting, controls etc. will be followed.

COMMUNICATION IS KEY

The basic difference between a HSR system and conventional railways is speed, and every system installed needs to respond very quickly to ensure overall safety of passengers as well as installations.

The MAHSR project will use the Digital Shinkansen-Automatic Train Control technology, which has proven to be highly effective in the Japanese Shinkansen system. When trains run at speeds of over 320 km/h, the driver sitting in the train needs to be in constant touch with the control room through a completely fail-proof system, which in case of HSR is achieved using a state-of-the-art radio system.

"In the proposed High Speed network of MAHSR, train protection system through DS-ATC is unique in its own way. The vital safety data related with next train on the same track is transmitted using railway tracks to the train. It's a highly-centralized system which has hardly any electronics placed by the track side. The safety performance of the system proposed is one of the best in world."

Sh Sandeep Kumar

DIRECTOR, ELECTRICAL AND SYSTEMS

In Europe, the vital communication on HSR systems happens through radio. But in India, a more conventional technology – track to train transmission – is used which is older but proven to be more reliable and effective. In this, the train control information is passed to the train through the track. Since the rail and wheels are always in contact with one another, the probability of loss of transmission gets reduced to a large extent as compared to use of air borne signals.

To make this communication system completely fool-proof, a fall back system is provided using a leaky coaxial cable on both sides along the track. The cable is hanging by the both sides of the track.

A HSR system is run on an intricate system of wires and cables that transmit a lot of information for its smooth and reliable running. In a month, if there are 100 issues coming up in HSR systems, an average 30-40 are caused by cable failures.

For the first time in India, the MAHSR corridor will use a gas-filled cable for transmission of vital information. If there is a damage to the cable, the system is immediately alerted and necessary corrective action can be initiated.

"Changeover switches or automatic switched neutral section arrangements planned in MAHSR, are based on proven equipment and technology in-use on Shinkansen network in Japan. No action by way of switching off and on of a train's Circuit Breaker is required by the driver/operator for negotiating neutral section thus no possibility of manual errors owing to fatigue etc. Here, the position of the train is sensed through the track circuit and neutral section initially is charged by the ongoing phase and thereafter by the incoming phase and the switchover time is less than 300 ms."

Sh Sandeep Kumar

DIRECTOR, ELECTRICAL AND SYSTEMS

For safety, the system ensures that the trains don't exceed the permissible running speed at any time. If the driver goes over it, a warning is issued and within a few seconds, the equipment takes over to reduce the speed of the train automatically.

This ensures that the chances of collision between two consecutive trains running on the system is reduced to nil. Similarly, the speed is also controlled at curves when the train speeds need to be lowered for safety. These locations are automatically stored in the system and warnings are automatically issued to the drivers to lower the speed.

An intricate network of connectivity is established on the entire HSR line. Every station has a Station Equipment Room (SER), which connects it to the tracks and other SERs for effective communication between the tracks and the trains. All the SERs are connected to the OCC so that the entire working of the system can be monitored and controlled from a centralised location.

Telecommunications

A HSR network has its own internal network of telecommunications, using their own optical fibre network. This includes:

- A dedicated telephone system that connects all the offices on the line
- A wireless communication link between drivers on every train and OCC
- A portable mobile phone for every worker on the field to alert them about an incoming train
- Yard radio systems for communication in depots
- CCTVs, centralised clock system and call recording systems

JAPANESE SIMPLICITY

The Japanese known for their simplicity and clutter-free approach which has found its way into our HSR system. The cab displays is one of the simplest in the world – the driver can see very few elements, such as the permissible speed of the train and the actual speed that the train is running at. This is a different design from the European train screens, which have several other controls and displays in the driver's display.

CATCHING THE **NERVE**

The nerve centre of the main train line is the **Operation Control Centre (OCC)**. It is from here that the train operations and services of the entire MAHSR line will be planned, executed, monitored, evaluated, recorded, analysed and influenced. At the OCC, officials can see the running of the entire system, including the movement and exact location of all the operational trains and all systems associated with the effective running of the HSR system in real time. The OCC for the MAHSR project will be located at Sabarmati.

Any problem on the system – in signalling or track or due to any weather calamity will be instantly visible on a screen in the OCC enabling quick redressal and correction.

THESE WAYSIDE SAFETY SYSTEMS ARE GOING TO KEEP YOU SAFE

- *Wind monitoring system to check the intensity of winds*
- *Rain gauges on tracks to monitor the level of rainfall*
- *Rail thermometers to monitor the temperature of rails*
- *Earthquake sensors placed along the tracks as well as at locations prone to earthquakes*
- *Protection systems on maintenance cars to prevent collision*

Each of these systems is linked to the OCC, where an alarm is set off in case safety parameters are breached. In case of an exigency, the OCC can alert the driver, or lower the speed of trains or even bring them to a complete halt.

All the trains will be serviced and cleaned following a meticulous maintenance plan comprising of daily, monthly and annual inspections of trains and installations to ensure safe and smooth operations and to enhance the life of the rolling stock. This will be done at Maintenance Depots which will come up at Thane, Surat and Sabarmati.

"Depot layouts were modified to suit land availability and Indian requirements. Similarly, the number of depot machines were also optimised to suit Indian conditions."

Sh Vijay Kumar
DIRECTOR, ROLLING STOCK

These state-of-the-art depots will be equipped with all modern facilities and robust Information Technology (IT) systems required for the upkeep of trains and all other installations that make the high-speed system work and have been designed keeping in mind the requirements and train loads right up to 2053 when the system is expected to run at full capacity.

The MAHSR corridor will be serviced by 3 depots, located at Sabarmati and Surat in Gujarat and Thane in Maharashtra. The largest of these is the Sabarmati Depot, which has the capacity to hold all of MAHSR's 1,136 cars for overhaul.

MOBILITY **FOR ALL**

The MAHSR line is an inclusive set-up that is equipped with a host of facilities to make facilitate its use by Passengers with Limited Mobility (PLM) and the elderly. Every train will have special seats and dedicated toilets for PLM and have been designed to allow for entry and exit of self-propelled wheelchairs. Escalators and lifts will be wheelchair-friendly and located in a manner that passengers can board the trains easily.

The entire infrastructure has been designed to meet their needs and requirements. An integrated element are braille signages and tactile flooring for visually impaired passengers, which will help them find their way around the station buildings, platforms and trains.

Special ramps and parking lots will be created for those with limited mobility, who will also have access to special assistance from staff at stations to ensure that their journey is comfortable and hassle-free. Provision is also being made to offer assistance to elderly passengers travelling on the HSR system alone.

CAPITAL MATTERS

The MAHSR project is coming up at an estimated cost of INR 1,08,000 crore (USD 17 billion), which will be executed with Official Development Assistance (ODA) Loan assistance from JICA.

For implementation of the project, a government to government cooperation agreement was formed between India and Japan to bring the Shinkansen technology to India and was signed in December 2015. An amount of umbrella funding was allocated in the diplomatic exchanges that followed, with the understanding that loans will be disbursed as and when the amounts are required with the signing of individual loan agreements.

In overall capital structure, 81 per cent will be funded from Government of Japan and remaining will be funded by Government of India (GoI). According to the equity structure of SPV, 50 per cent is held by the GoI through the Ministry of Railways, and 25 per cent each by the Government of Maharashtra and the Government of Gujarat.

The MAHSR project is one of JICA's marquee projects as it accounts for nearly 50 per cent of their portfolio in India, even though they are heavily invested in the country.

So far, NHSRCL has signed several loan agreements and many contracts have been awarded for the MAHSR corridor including one of south east Asia's biggest infrastructure contracts.

The funding has certain conditions, which are clearly mentioned in the government to government exchange. The loan is only for construction expenditure of the project, and not for land acquisition, rehabilitation or resettlement expenses, taxes, utility diversions, etc. All of these are to be funded from equity or by other means.

> *"The loan conditions for the MAHSR are very attractive. It is a 50-year loan at 0.1 per cent, a rate that normally does not appear in JICA's portfolio. This includes 15 years of loan repayment moratorium, and then 35 years of loan repayment with interest. It is a concessional rate offered to India for the HSR project after a special approval from the Japanese Cabinet."*

Sh AK Bijalwan
DIRECTOR, FINANCE

Avenues of revenue

No mass transportation project of this scale can be viable just by fare. This is the first HSR project in India and there is no precedence, but references can be drawn from Japanese railway companies and also from Delhi Metro in India.

The MAHSR line is not just a mass transportation project. It is an urban development project where the stakeholders are many. Countries like Japan have imaginary concentric circles to define prime catchment areas, municipal areas, industrial areas where development emanates around the HSR stations that come up. India will also be looking to introduce something along those lines.

> *"We at NHSRCL believe that being a cutting-edge technology infrastructure project, innovation should not be restricted to only technical matters. Therefore, even in areas of revenue generation, a broad-based multipronged approach going beyond fare earnings has been envisaged."*
>
> **Sh AK Bijalwan**
> **DIRECTOR, FINANCE**

To generate non-fare revenues, NHSRCL plans to develop three stations – Sabarmati terminal, Vadodara and Surat – for real estate development. Secondly, they will engage with municipal authorities and develop the area around the stations. This results in an increase in land prices and revenues for governments. The world over, it has been seen that revenue increases range from 0.5X to 6X with the development of HSR lines.

The Sabarmati Terminal building, where three modes of transport will integrate, will have 13 floors which will be leased as part of property development. Other avenues being explored include advertising, leasing of space to corporates and individuals, among others.

Finance for land acquisition

To make way for construction of the MAHSR corridor, NHSRCL needs to acquire nearly 1,400 hectares of land in state of Gujarat and Maharashtra and Union Territory of Dadra and Nagar Haveli which is classified under four broad heads – private, government, railway and forest land.

Land acquisition also includes resettlement and rehabilitation of the Project Affected Families. For the MAHSR project, the complexity of this issue is very high. There are more than 4,000 families that need to be resettled across 2 states, 1 union territory, 12 districts and around 1,400 hectares of land.

If one were to compare this to another project of this scale, say the construction of an international airport at Jewar, the number of villages impacted is just 8 compared to 297 in the MAHSR project.

All of the affected families need to be given compensation, or requisite accommodation, which is calculated based on an entitlement matrix to make the process completely transparent.

In Maharashtra, land acquisition is being done based on government orders and NHSRCL is following the Competent Authority of Land Acquisition (CALA) system where the State government has been entrusted the power to acquire the land and NHSRCL is only the paying authority.

A tripartite arrangement has been created for efficient pay out of compensation amounts to thousands of beneficiaries from whom land will be acquired for the project. Three bank clusters have been selected to disburse payments – ICICI, HDFC and SBI – and for each cluster, a daily estimate has been prepared based on which funds are transferred to Land Acquisition Officers (LAOs). The LAOs in turn pay the required amounts to beneficiaries. The entire transaction is completed in one day, and NHSRCL gets a statement of all the payments made at the end of each day.

Chapter 5

A RIDE WITH TWISTS AND TURNS

A project of this magnitude that spreads across two Indian states with diverse cultures and governance systems has thrown up a host of challenges for NHSRCL along the way.

> *In a project of many firsts, each of these challenges has been an uphill task, in terms of numbers, magnitude or technical difficulty. The teams at NHSRCL have put in gruelling hours of brainstorming both internally and with external agencies to come up with solutions."*

Sh Achal Khare
MANAGING DIRECTOR

Challenge 1: Mapping of utilities and their diversion to clear way for construction of the MAHSR corridor

Both the states that the MAHSR corridor passes through fare high on the development index and have widespread economic activities. To power this growth and development is a dense network of utilities such as electrical lines, telecom and fibre networks, water pipes, sewerage connections, etc. Many of these utilities fall on the alignment of the upcoming high-speed corridor, and need to be shifted to make way for construction activities and the smooth running of train operations at a later date.

While some of the utilities are easy to spot, many are not visible on ground or over the ground. The only way to map them is by identifying all the utility owners operating in that area and using tools such as ground penetration radars to carry out joint surveys. Once the coordinates are known, these are marked on the alignment to identify the ones which will infringe the Right of Way (RoW) and need relocation.

The magnitude of the issue is very unique in this project as compared to other railways projects. Conventional railway lines pass through a combination of greenfield and brownfield areas so the number of utilities to be shifted is not as many. Mapping tower footings an area which is highly developed and has very little space availability poses a real challenge.

Furthermore, a large portion of the MAHSR corridor will run on viaduct, with an average height of 10-12 m above ground. Due to this, about 1,650 electrical utilities needed to be shifted too. This number would have been much lower had the construction and operations of the line not been at such a height.

As a comparison, in dedicated freight corridors, where there is a requirement of about one utility relocation per kilometre, this number already stands at more than 5 utilities per kilometre for MAHSR corridor, excluding 21 km of tunnels. The overall utilities which have been identified are over 5,000 taking this number to over 11 utilities per km.

High-tension power cables and towers were shifted in order to make way for MAHSR corridor

The numbers are much higher even compared to Metro lines due to the sheer length of the corridor. The length of an average Metro line is about 25-30 km. The entire network of Delhi Metro is about 300 km, which has been constructed in phases, which is about half the length of the MAHSR corridor. Also, Metro projects come up in city areas where carrying out foot mapping is simpler. Train corridors pass through areas like hills, dense forests where accessibility can be a challenge.

In the MAHSR corridor, all the utilities which infringe the RoW either need to be shifted underground or raised to a substantial height so as to ensure that they do not interfere with the running or construction of the high-speed line. The height of the deck itself is planned at 10-12 metres, above which lie the overhead electrical lines. During construction, girder launching machines working also require a minimum height clearance to ensure safety.

In order to speed up the process, NHSRCL has deployed several technologies, including Ground Penetrating Radar (GPR) surveys which sense the presence of a metallic object under the ground. The details thus collected are verified with the agencies and the utilities identified.

LiDAR

Time is a critical factor for a project of this scale and magnitude. For construction activity to start on the MAHSR corridor, NHSRCL first needed to finalise the exact Right of Way (RoW) of the entire stretch in order to finalise the actual path of construction on ground.

The project is spread across 508 km over mixed terrain, which includes highly populated areas like Mumbai, Ahmedabad and Vadodara, Ghaat sections, creeks, where it can be difficult to carry out foot surveys by physically entering the areas.

After evaluating several options, the MAHSR project is the first railway project in the country to make use of aerial LiDAR survey to finalise the exact RoW. Here, a helicopter fitted with special aerial LiDAR sensors, a camera, an Inertial Measurement Unit (IMU), a GPS and a computer is flown over the route to scan it in detail.

LiDAR works on the principle of light detection and ranging where laser pulses are fired from the helicopter to scan the ground. The data thus collected over for the entire stretch was further processed and used to create a digital terrain surface and digital elevation model.

This has been used to design various structures that are coming up for the MAHSR corridor, to finalise the Right of Way and the exact amount of land required.

For NHSRCL, the use of LiDAR has resulted in major saving of both time and resources, without compromising on accuracy. LiDAR has reported very high levels of accuracy as there is no manual intervention in the process and also provides data below vegetation and forest cover. Overall, the total survey time was just 3 months, which would have otherwise taken 12 months using other means.

Relocation of oil wells

Five ONGC oil wells located in Nandej, about 15 km from Ahmedabad, which are very close to the alignment had to be relocated in compliance with a code of practice as per which a railway line cannot exist within a 50 metre radius of a functional oil well for reasons of safety. NHSRCL went ahead with the capping of these oil wells and coordinated with ONGC to relocate them.

A lot of heavy machinery was used in the process to ensure that the capping is done properly, so that there is no eventuality in the event that the capping comes off. The marathon process from identifying the wells to their capping took about 1.5 years and the work has been successfully completed.

Aerial LiDAR Survey was used for the first time in India for any railway project to finalise Right of Way for MAHSR corridor

Challenge 2: Land acquisition

In case of high-speed corridors, the path of the track cannot be significantly altered as any sharp curves on the route are undesirable. So, getting the exact patch of land as earmarked in the alignment study is important.

The primary challenge with land acquisition is resistance from people. Making the land users understand how they will be benefited from this process of land acquisition was a very important factor. The amount of compensation is also important as is the trust that they are going to get the money promised to them. The compensation was to be paid in accordance with the land acquisition act, which works out to four times the market rate in rural areas and twice the market rate in urban areas.

NHSRCL followed a process of acquisition through the land act of the State government, which provided for an option of extra incentive over and above what is specified in the land act to encourage land acquisition by consent.

Complete transparency was followed for the entire process. When NHSRCL finalised the entitlement matrix, they gave people examples of how the compensation is going to be calculated.

When a decision was taken to adopt the Gujarat Amendment Act, there was a provision of consent where land owners were entitled to 25 per cent extra compensation. On ground, the first step towards this is a census survey to get details of the affected families and their monthly household incomes.

NAVSARI POSED A UNIQUE CHALLENGE

In Navsari District of Gujarat, the land owners wanted parity in compensation as they felt that the compensation amount in the adjacent district was much higher. The Gujarat government stepped in to proactively revise the rates and finally, the land acquisition in this area became the fastest in the entire state. In a span of two and a half months, 80 per cent of the land has been acquired.

A Social Impact Assessment (SIA) study is mandatory to publish a notification in the newspaper for a field survey. And for the notification, you have to have details of the land owners, which you cannot do unless you go to the field. Gujarat enacted an amendment wherein they exempted SIA for linear projects, and NHSRCL was able to issue a notification after carrying out preliminary field surveys.

After the notification is issued, a detailed field survey is carried out wherein a central line is marked to get the exact details of land that needs to be acquired. The accuracy level is 70 per cent after the desk study in the notification stage, which increases to 95 per cent correct after the central line is marked and the details are transferred on to a revenue map. A 100 per cent accuracy comes only after a joint measurement survey is carried out.

Once the details of the land owners were ready for the state of Gujarat, consent camps were organised at the district level to disseminate information about the compensation. To build greater trust, they were given 80 per cent of the compensation with 3-4 days of signing the consent agreement. This had a cascading effect on consents, where more and more people started coming forward.

At these camps, district officials also came and updated the revenue records, which also accelerated the process.

Joint Measurement Survey at Boisar HSR Station site

In 2018, Maharashtra enacted an amendment to their Land Act, making it similar to Gujarat. The payment for land includes direct compensation and a R&R component also. There is a unique challenge in R&R in Ahmedabad, Vadodara and Vasai, where the piece of land to be acquired is owned by someone but someone else is living in it, who wants an alternate accommodation. In this case, the solution is not just a simple pay out of compensation based on some calculations but also arranging for that alternative housing. In Vasai alone, about 1,800 homes have been identified with such a problem as the density of population is very high.

THE PALGHAR CHALLENGE

In Maharashtra's Palghar district, NHSRCL faced a lot of trouble with getting land. There is resistance from local forces, who oppose new projects coming up in the area even though they are not the real land owners who will be affected by the land acquisition process.

Another big issue was Gola land, which is a land with multiple owners, the numbers for which can go as high as 90 people for the same piece of land Palghar district has a sizeable number of such Gola land plots, where finding the correct recipient of the compensation is posing to be a challenge.

NHSRCL also faced issues with adhivasi land where the owner of the land is not the person using it. There are tillers whose livelihood depends on that piece of land so they also need to be compensated. But the problem is how to identify the tiller in the absence of proper government records. NHSRCL has reached out to gram panchayats to find out the tillers.

This is not all. There is an issue with forest land. This land belongs to the government but is occupied by tribals. In such cases, consent from the gram panchayats is required as the livelihood of these tribals depends on the forest – be it for the food, wood, etc.

Challenge 3: Saving the environment

Large-scale infrastructure projects mark growth and progress for cities that they touch. But, sometimes, the construction and commissioning can cause damage to the environment. In case of the MAHSR corridor, special efforts have been made to ensure that some of the ecological hotspots for wildlife in north-western Maharashtra – Sanjay Gandhi National Park (SGNP), Tungareshwar Wildlife Sanctuary (TWS) – which the alignment for the high-speed train touches, are not adversely impacted due to this project.

SAVE THE TREES

Thousands of trees were saved as a voluntary initiative by NHSRCL – a massive transplantation drive. A large number of trees were saved using the innovative tree spade technique, in addition to the mandatory plantation which was done for the number of trees being affected by the project. The tree transplantation is done in a ratio of 1:10 in municipal areas, 1:5 in mangroves and 1:2 for other trees. The transplantation is over and above that, for which there is no legal binding on the part of NHSRCL.

Due to its proximity with Mumbai, this area have been selected for three major infrastructure projects coming up in the region – the MAHSR corridor, a Diva-Panvel railway line, a DFCCIL track and a future expressway planned by MMRDA – all on a 80-100 metre path between SGNP and TWS.

Graphical representation of Wildlife Animal Corridor

Even as the development is good news for those living in cities surrounding this area, the large-scale construction would cause a major dislocation for wildlife. After several rounds of deliberation between the various stakeholders, a decision was taken to create an animal corridor – with an underpass and overpass – which will offer a smooth passage for movement of wildlife in the affected areas.

The overpass, with a width of 30 metres, will come up over the existing Diva – Vasai Line, proposed DFCCIL line and PWD road and will be below the MAHSR line and MMC viaduct. Its design will match the natural vegetation of the surrounding areas, and elements like rocks, logs and water bodies will be added to make the animals feel at home.

Restrictions will be imposed on the use of heavy lighting in the area and high-quality noise barriers will be erected so as to ensure that the levels stay within safe ambient limits for the animals.

The alignment of the MAHSR corridor also passes underground in the area of a Flamingo Sanctuary. Here, naturalists were of the opinion that the tunnelling process which will be used to construct the tunnel for the high-speed train line will cause vibrations. This process, in turn, would cause the mud flat in the area to settle down.

Flamingos feed on fish that thrive in this mud flat and, therefore, any changes would affect their food flow, forcing the birds to migrate to other areas. In a proactive move, NHSRCL got a study conducted for the same, in which it was concluded that the vibrations would be much below the safe limits.

The report was submitted to the Wildlife Board and has been accepted. NHSRCL, on their part, were earlier considering the New Austrian Tunnel Method (NATM) to construct the tunnel as it saves costs. But, that method requires access to the underground through shafts, which were not possible to create in this area. So, a decision was taken to modify the method of construction to Tunnel Boring Machine (TBM).

NHSRCL also carried out a physical counting of the number of mangroves which will be needed to cut in the Mumbai area to make way for construction, for which a special permission is required from the High Court which has stayed all cutting of mangroves in the Mumbai area.

For every mangrove that is affected, NHSRCL has deposited money in the ratio of 1:5 towards compensatory afforestation. So, even though the affected mangroves are around 22,000, around 1,60,000 new mangroves will be planted and the expense will be borne by NHSRCL.

Challenge 4: Vadodara HSR station

In the feasibility report of 2015, when the initial survey for alignment of the MAHSR line was carried out, an attempt was made to bring the HSR station as close to the city centre as possible in major cities like Vadodara, Ahmedabad and Sabarmati so that more and more people can use the system.

In Vadodara, the HSR station was brought in the vicinity of the Indian Railways station to enable easy transfer of passengers between the two modes of transport and enable Multi Modal Integration. But, this alignment proved to be a major challenge for NHSRCL for a variety of reasons.

Firstly, the HSR alignment was designed to cross the yard from east to west, over almost 13 lines. The spans of steel bridges proposed to make this crossover were 100 m + 220 m + 120 m, which is higher than what has ever been constructed for a Japanese Shinkansen high-speed network. About 25,000 MT of steel would have been required for the bridge construction.

To enable this construction, the process of launching a temporary girder over the main lines and rotating, with trains running underneath, would have been a major challenge. Moreover, the estimated time for fabrication of the steel girder and launching was 66.6 months, a delay the project timelines didn't allow. The site of construction also fell in the flight paths of aircrafts at the Vadodara airport, due to which an air space clearance was mandatory from Airport Authority of India. The permission was denied as the launching of girders required the airspace to remain closed.

After several rounds of discussion, the alignment of the line for a distance of about 4.3 km in this section was changed to cross the tracks ahead of the railway yard. By doing this, the HSR alignment crossed the Indian Railways tracks with ordinary spans of 40 m on portal piers.

This change resulted in time savings, considerable reduction in designing time and financial saving of about INR 2,000 crore. The new station location thus found also offered better multi-modal integration as it is now closer to a local bus depot with better road connectivity too. Major displacement of home and commercial units was also averted due to the changed alignment, making it a win-win for all.

Challenge 5: Modifying Shinkansen installations to suit Indian conditions

The MAHSR corridor is modelled on Japan's well-established Shinkansen network. While the processes and equipment can be replicated in India, the one thing we cannot alter is our weather and dust conditions, which are very different from what is found in Japan.

The Gujarat – Maharashtra area sees temperatures soaring to over 50 degrees and very high levels of dust, while Japan is a dust-free environment with moderate summers and snowy winters. Temperature, dust and humidity are all hazardous for expensive HSR installations.

NHSRCL is bringing in some of the trains from Japan to run on the new line. But, when the trains were being designed for Indian conditions, certain modifications needed to be done to meet our requirements. All electrical devices have certain margins built into them. The design limit has to be greater if there are temperature variations, like what we see in India (from -5 to 50 degrees).

When you redesign for higher temperatures, the weight for that equipment increases because you need more cooling arrangements. And, with an increased weight, the power of the train also needs to be increased to achieve the desired high speeds, which brings down its energy efficiency.

Another factor affecting the load on trains is the average weight of the Indian passenger, along with the amount of baggage carried by us, which is also higher than the average Japanese passenger.

In addition to modifications in trains, the structures within maintenance depots where this machinery will be placed have been designed in a manner that allows for a 10 degree drop in ambient temperatures, using measures such as roof sheeting, exhaust fans, reflective paints on exterior walls.

Challenge 6: Optimising water utilisation in rainfall-scarce Sabarmati

Sabarmati Depot is the largest of the three Rolling Stock depots which will cater to the MAHSR Corridor and has the capacity to service and overhaul the entire fleet of 1,126 cars that will be pressed into service on the line.

Such a massive facility has an estimated water requirement of about 20 lakh litres per day when the line is running at full capacity. Owing to its location in an area where water is a scarce resource, the depot has been designed with the latest water resource management techniques which ensure that 70 per cent of the depot's daily water requirements are met with water recycled inside the premises.

To make this work, the depot is equipped with a state-of-the-art **rooftop rainwater harvesting system**. It will collect rain water which will be stored in massive tanks created under the depot building, parking lots, traversers, etc. The water will be treated and used for domestic purposes.

The sewage from trains will not be dropped on the tracks but brought to the depot and also treated and recycled in a modern **sewage treatment and effluent treatment plants**.

The storm water flowing on ground, or water that overflows from the rooftops, will be utilised towards recharging the groundwater. For this, **a network of percolation wells** is being created across the depot. This will protect the depot from getting flooded and also recharge the ground water aquifers. The remaining water will flow into landscaped water bodies created within the depot through the same network.

This will protect the depot from getting flooded and also recharge the ground water aquifers. The remaining water will flow into landscaped water bodies created within the depot through the same network.

The entire system has been designed using the most modern techniques available and is in compliance with guidelines of the Central Ground Water Board (CGWB). It ensures complete optimisation of rain water in the depot premises, thereby saving gallons of the precious natural resource.

Chapter 6

TECHNOLOGICAL MARVELS

From a tunnel that bores under the Arabian Sea to preserve the ecology in the Thane creek area to a HSR station being constructed over operational Indian Railways tracks which see hundreds of trains pass through every week, the Mumbai – Ahmedabad project has its share of technological marvels which will make us proud. Each of these solutions showcases cutting-edge innovation in engineering design and world-class construction technologies. Though the list is exhaustive, these are some of the highlights.

Undersea Tunnel

The alignment of the MAHSR corridor features a 21 km-long tunnel, a part of which is going to run under the sea bed. This is going to be the first under sea tunnel to come up in the country. The tunnel will start from Mumbai's BKC station and come out at Kalyan Shilphata, of which about 7 km runs under the Thane creek, an ecologically sensitive zone which is home to a wide variety of rare flora and fauna.

About 1.8 km of this tunnel will be constructed under the sea bed, while the remaining part on either side lies under the mangroves on either side of Thane creek.

The entire 21-km stretch will be constructed using a combination of two techniques – New Austrian Tunnelling Method (NATM) to carve out 5 km of the tunnel and Tunnel Boring Machine (TBM) for the remaining 16 km. NHSRCL plans to get 3 TBMs for the tunnelling process. Each of the TBMs will progress at a speed of 200-300 m per month.

The reason for using both techniques is to save time as well as remove the requirement for a shaft in the area, some of which falls under the sea bed and some under a flamingo sanctuary and mangroves.

There was a requirement for creation of equipment rooms at every kilometre inside the tunnels. When the tunnel is being constructed using NATM, this is simple to do. But, for the part when TBM will be used, the RC lining of tunnel walls fitted after the tunnel is carved out will be replaced with a steel lining. This can be later be cut to create space for the equipment rooms. In all, about 38 such equipment rooms will be created along the entire 21 km tunnel.

A single tube of 13.2 m diameter will carry both the tracks in the tunnel and the diameter is the largest for any railways project in India, another first. To study the structure of the sea bed, a Static Refraction Technique (SRT) survey was carried out by a team of engineers from NHSRCL, RITES and Japan's Kawasaki Geological Engineering Firm. For this, a high energy sound wave was fired towards the sea bed from below the water surface to help determine the density of rock under the sea bed.

Seismic Refraction Technique Survey in progress in Thane Creek (December 2017)

In addition this under-sea, the MAHSR corridor has eight more tunnels which will come up in mountainous areas, all of which will be created using NATM.

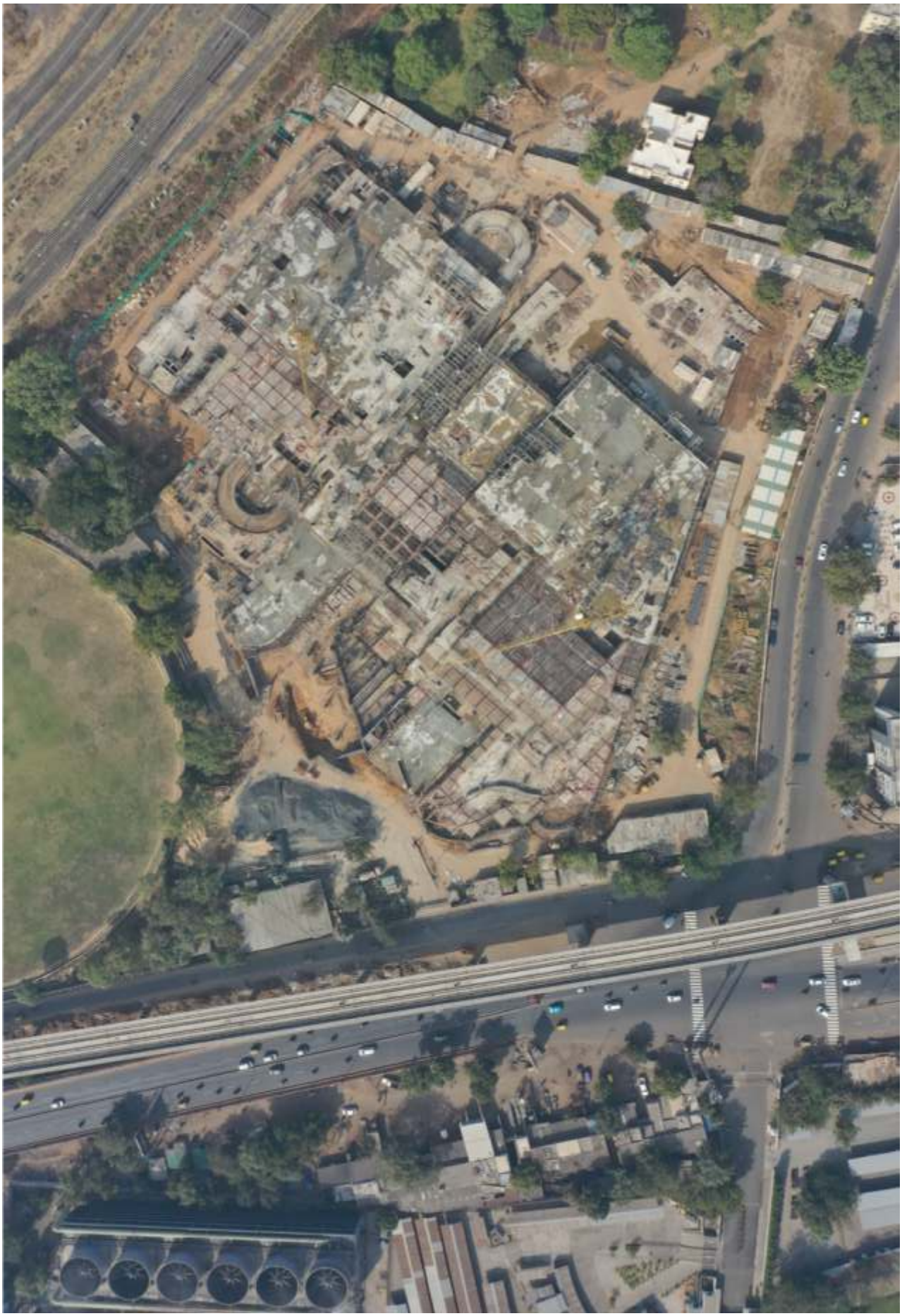
Sabarmati Passenger Hub

In a unique arrangement, Sabarmati Passenger Hub is being developed as a Multimodal transport hub for the region which will connect the Sabarmati HSR Station to Indian Railways station, Ahmedabad Electricity Company (AEC) Metro station and a Bus Rapid Transit (BRT) system, all located within a short walk for easy transfers.

To provide seamless connectivity, three foot overbridges (FOBs) are being constructed in the transport hub. The first one, with a width of 10 metres, connects the terminal hub building with Sabarmati Railway station on the eastern side. It will be fitted with travellators. A second FOB will connect the unpaid concourse area of the HSR to that of the AEC Metro station and the Sabarmati Power House BRTS station. A third FOB will connect the unpaid concourse of the HSR station with railway platforms of the Sabarmati broad gauge railway station (west side).

With a total covered area of about 1,33,000 sq metres, the terminal building is being constructed as a twin structure with space earmarked for government offices, commercial development and retail outlets for passengers. A parking space for 1,115 cars and 300 two wheelers is being provided for use by passengers using any of the modes of transport or facilities at the hub. For easy access to the terminal building, dedicated pick up and drop off bays will be created for private cars, taxis, buses, autos and two wheelers.

Graphical Representation of Sabarmati Passenger Hub



Sabarmati Passenger Hub construction site

Chapter 7

USHERING A NEW INDIA

A high-speed rail link will act as a catalyst for change for the country and will help redraw the map of India's economic development, thereby creating a strong foundation for future growth.

An infrastructure project of this scale and magnitude will act as a magnet of development for the country as a whole. The upcoming HSR systems will offer benefits of connectivity bringing rural and urban economies closer, adding to our technological prowess and creating thousands of employment opportunities.

In this story of development of India, the role of NHSRCL is much more than just facilitating the construction of the high-speed rail line from Mumbai to Ahmedabad.

Make in India

The construction of this iconic railway line will have a strong 'Make in India' component. An integral component/part of the MAHSR project is Transfer of Technology (ToT) and making India a part of this development story.

As a step towards being atma nirbhar (self-reliant), all the civil construction packages contributing to about 70 per cent of the construction cost are open to Indian contractors. This includes a challenging 21-km large diameter (13.2 m) tunnel section, of which 7 km lies under the sea.

Furthermore, six train sets to be run on the high-speed line will be partially assembled, commissioned and tested in India itself offering the know-how of the rolling stock. The first 18 high-speed train sets will be brought in from Japan.

With Japanese collaboration, and India's quest to place itself on the Global HSR map, one of ToT initiatives entails opening up track construction to Indian contractors. An elaborate facility is being created at Surat for this, wherein the staff from the contractor will undergo training and certification for Shinkansen track technology by experts from Japan. As per the plan, about 1,153 personnel will be trained in Shinkansen construction technology and O&M procedures.

The idea is to give Indian engineering, technology, construction, manufacturing and other allied industries a much-needed boost, which will place them on the Global map for competence. Indian companies will meet global standards in creation of parts as well as fitting of tracks.

Some of the areas identified for 'Make in India' include:

- Traction and distribution systems (almost the entire set of equipment) which includes Various types of transformers, switchgear and protective equipment (circuit breakers, disconnectors, lightning arresters etc), cables, connectors, ducts
- Battery sets
- Generators
- Overhead equipment poles

- Telecom equipment
- Optical fibre cable
- IP Network
- Wayside protection boxes
- Fasteners for track system
- Depot sleepers
- Track slabs
- Rail turnover prevention device

Innovating for a Brighter Future

Known for its technological prowess, India has all the tools and acumen needed to secure a spot on the Global technology map. To leverage these technical capabilities and offer a one-stop solution to all issues and queries related to HSR systems in the region, NHSRCL set up a HSR Innovation Centre on January 22, 2019.

The centre is tapping the technical capabilities of some of our best minds and develop indigenous capabilities and professional expertise in all aspects of HSR with an aim to provide innovative, indigenous, cost-effective solutions, technical guidance, strategic analysis and advise to the Indian rail transportation industry on significant challenges and opportunities.

It will also contribute towards development of HSR specific standards for India, where the technology is new and we have no precedents or SODs.

The set-up is managed by a Board of Trustees chaired by Managing Director, NHSRCL and supported by the Executive Council and assisted by the Advisory Council, which is entrusted with the task to review the nature of projects that should be undertaken at the Innovation Centre.

This Advisory Council have as members persons of repute from academia and research institutes both from India and overseas, including Indian Institutes of Technology (IITs) at Roorkee, Delhi, Bombay, Gandhinagar, Kharagpur, Advanced Manufacturing Technology Development Centre (AMTDC) of IIT Madras, IISC Bangalore, Ahmedabad Textile Industry's Research Association and University of Tokyo, and Railway Technical Research Institute (RTRI), Japan. The trust will adopt a collaborative approach for funding as well as execution of research projects.

Joining the League of Global HSR Leaders

NHSRCL became affiliate member of UIC on 30th June 2020 and is also de facto member of Asia Pacific region and member of UIC's Intercity and High Speed Committee (ICHSC). This membership is helping NHSRCL gain knowledge of best practices, participation and interaction with several HSR experts in meetings related to finalisation of HSR standards, exposure to available global technologies, construction methodologies, maintenance practices, research and innovation ideas, training opportunities etc.

A Future-ready Workforce

A state-of-the-art centre for advanced training on cutting edge technologies needed for HSR is being constructed at Vadodara, Gujarat. NHSRCL's High Speed Rail Training Institute (HSRTI) will be equipped with the best in class training equipment including simulators, model rooms, slab track, etc to train our HSR staff on use of Shinkansen technologies and processes which will be needed to run the MAHSR corridor.

The training institute will train about 3,500 employees from different specialty areas such as Rolling Stock, Civil and track Maintenance, Electricals, Signalling and Telecommunications, to equip them with the right skillsets to operate and maintain the HSR corridor.

"HSRTI is being conceived as a one-of-its-kind educational hub in the country for design, development and delivery of HSR training programs. It will have a strong focus on imparting instructions through customised training programs for topics ranging from construction, project implementation and management; and operations and maintenance."

Sh AK Bijalwan
DIRECTOR, FINANCE

GOING DIGITAL

Keeping up with changing times, NHSRCL was quick to make the switch to a digital working which also helped during the pandemic, where systems were already in place to make sure that work didn't stop. The execution of the MAHSR project – which is anyway on a tight deadline – continued on full-steam. To enable this, an integrated system was put into place connecting NHSRCL's corporate office with Chief Project Manager (CPM) offices at the project site, Project Management Consultants (PMC), Contractors and also allowing for status reporting via mobile phones. The key areas covered were document and drawing management, scheduling and progress management, contract management, to name a few.

To facilitate the training for Operations and Maintenance, a team of 360 employees from NHSRCL will be trained in Japan of which 78 will also undergo specialised on the job trainings for expertise in specific domains.

NHSRCL executed a MoU with Japan Railway Technical Service (JARTS) on April 19, 2021 under which more than 1,000 engineers and supervisors from NHSRCL will be trained in specialised slab track system for track laying in the Japanese Shinkansen system, which is being used on the MAHSR corridor.

The trainings will be based on what is followed at the Shin-Shirakawa institute in Japan, in order to get the best experience and expertise for the Indian staff.

The institute will have a ballastless slab track and simulators recreated in the campus to offer practical training, which will help bridge the skill gap in the HSR sector and build a pool of skill resources who are skilled in every aspect of HSR technologies. The classrooms will be state-of-the- art too, equipped with internet enabled KYAN interactive projectors, smart boards, LED panels, AV speaker systems and trainee laptops. Training programs will be supplemented with on-the-job training for maximum retention on real HSR projects.

"All the early employees of NHSRCL, at all levels of seniority, have undergone basic Japanese language and cultural training organised in collaboration with Japan foundation."

Sh AK Bijalwan
DIRECTOR, FINANCE

High Speed Rail Training Institute Hostel Building in Vadodara

Mobile health unit donated by NHSRCL in Maharashtra region

Building a Brand

The task of NHSRCL's communication team is not just limited to internal and external information dissemination, to make sure that all details about this mammoth project and its progress are made available to the concerned parties using tools like media, social media and through the NHSRCL website, which is available in five languages.

In addition, there is a dedicated website in Marathi for the Maharashtra region, which is used to give out important information about the MAHSR corridor and to deal with any kind of misconceptions about the project.

Another core area of communication for NHSRCL as an organisation has involved meeting with all the stakeholders of the project and making them understand the gains from it for the regions affected and also for the nation as a whole.

NHSRCL has also been setting up consent camps to ease out the process of land acquisition, a task that became a major challenge owing to resistance from the local population whose plots needed to be taken over to make way for construction of the MAHSR corridor.

The task involved explaining the project and its benefits to affected parties and also apprising them of the compensation and its calculation. The main idea is to make land users understand how they will benefit from this process of land acquisition. Those taking the consent route stand to gain as they are paid a certain amount over and above the compensation that works out.

Empowering our Stakeholders

In an attempt to equip project affected families with a skill-set to create a means for income generation and equip the youth with skills to make them atma nirbhar or self-reliant, NHSRCL has been organising specialised trainings for skill development in areas which the MAHSR corridor will pass through.

The trainings are being conducted under the Income Restoration Program and cover a wide crosssection of disciplines, from hotel management, computer hardware and networking, welding and fabrication, computer accounting, mobile repairing, electrical works, office automation, tailoring among others. Hundreds of people have been trained and a large majority have gained employment using expertise from the programs.

Construction training, Ahmedabad

Tailoring course, Ahmedabad

Electrician training course, Palghar

Motor mechanic training, Gujarat

Consent camp, Gujarat

Looking ahead

The MAHSR corridor marks India's foray into the world of HSR. While planning and executing tasks related to the construction and future operations of the Mumbai – Ahmedabad corridor, NHSRCL has gained knowledge and acquired technical expertise in all aspects of HSR. The organisation is now in a position to offer expert advice in the planning for other HSR corridors in the country.

Even though the MAHSR corridor will be using the Japanese Shinkansen technology, detailed studies undertaken by expert teams at NHSRCL over the past five years have placed them in a position to appreciate and evaluate other technologies which are currently in use in high-speed systems around the world.

NHSRCL can take on the role of a technical expert for all matters related to HSR systems, right from preparation of Detailed Project Reports (DPRs), construction, execution and operations.

With the process of awarding of civil contracts, the construction of the Mumbai – Ahmedabad corridor has begun on ground using international best practices. The path for the new train link has largely been cleared out and one can now see the first signs of this technical marvel rolling out right before our eyes.

The future is bright. India is now taking giant steps in this journey towards building a prosperous future for its people, both socially and economically.

Chapter 8

THE TEAM

This is the team of top management who have steered the journey so far at NHSRCL and without who's expertise the progress so far would not have been possible.

Sh Achal Khare
MANAGING DIRECTOR

Sh A K Bijalwan
DIRECTOR FINANCE

Sh Rajendra Prasad
DIRECTOR PROJECT

Sh Vijay Kumar
DIRECTOR ROLLING STOCK

Sh Sandeep Kumar
DIRECTOR ELECTRICAL & SYSTEMS

Executive Directors (in alphabetical order)

Sh Alok Katiyar
ED/SIGNALLING & TELECOMMUNICATIONS

Sh Amiyansu Das
CPM/SURAT

Sh Anjum Pervez
ED/PLANNING & DEVELOPMENT

Sh Brijesh Dixit
ED/DEPOT & MACHINERY

Sh Dipak Roy
CPM/PALGHAR

Sh H.L. Suthar
ED/DESIGN

Sh Pramod Sharma
ED/CONTRACT

Sh Prashant Mishra
ED/ELECTRICAL

Sh Sandeep Srivastava
ED/ROLLING STOCK

Sh U.P.Singh
CPM/MUMBAI

Key: ED: Executive Director / CPM: Chief Project Manager

Senior Advisor & Advisors (in alphabetical order)

Sh S.N. Agarwal
SENIOR ADVISOR/
CO-ORD/MUMBAI

Sh Ajit Pandit
ADVISOR/CIVIL
(AHMEDABAD)

Sh P. K. Sanghi
ADVISOR/CIVIL-1

Sh S.K. Mallik
ADVISOR/FINANCE

Sh Sudarson Nayak
ADVISOR/OPERATIONS & SAFETY

General Managers & HoDs (in alphabetical order)

Sh Abhishek Swami
GM/RESOURCE
MOBILISATION

Sh Akshay Kumar Marantu
GM/CONTRACT

Sh Alok Tripathi
GM/INNOVATION

Sh Amol Kr. Pingle
GM/SIGNALLING &
TELECOMMUNICATIONS
(VADODARA)

Sh Arun Kumar Singh
CPM/CIVIL (AHMEDABAD)

Sh D. P. Singh
GM/DESIGN

Sh Indudhara Sastry
GM/CONTRACT

Smt Kamini Sharma
CHIEF ARCHITECT

Sh Mohit Lila
GM/PLANNING &
DEVELOPMENT

Sh O.P. Gupta
GM/SIGNALLING &
TELECOMMUNICATIONS (MUMBAI)

Sh Pankaj Uke
GM/OPERATIONS
(MUMBAI)

Sh Pradeep Ahirkar
CPM/VADODARA

Sh Punit Agrawal
CPM/ SYSTEM
(AHMEDABAD)

Sh Ravindra Kumar
GM/HUMAN RESOURCE

Sh Satya Prakash
DIG/SECURITY
(PALGHAR)

Sh Surinder Pal Singh
GM/QUALITY

Sh Vivek Prakash Tripathi
GM/FINANCE

Smt Sumita Sharma
COMPANY SECRETARY

Smt Sushma Gaur
ADDL. GM
CORPORATE COMMUNICATIONS

Key: GM: General Manager / CPM: Chief Project Manager
HoD: Head of Department / DIG: Deputy Inspector General

Let’s take a trip down memory lane and look at this careful selection of the moments that team NHSRCL has shared together over the past few years.

Contract Agreement Signing Ceremony for Package C-4 (November 26, 2020)

Contract Agreement Signing Ceremony for Package C-6 (December 16, 2020)

Contract Agreement Signing Ceremony for Package P-4 (February 22, 2021)

Senior Officials at High Speed Rail Training Institute Construction site at Vadodara

Senior officials addressing a gathering

A momentous occasion for NHSRCL upon receiving 'Kalam Innovation in Governance Award'

NHSRCL Vadodara team with senior management

Learning/Collaborating with Japanese counterparts

Foundation Day Celebrations

MD Award winners on 5th Foundation Day celebration (2021)

Unveiling the Corporate brochure on 4th Foundation Day (2020)

Lamp Lighting Ceremony on 3rd Foundation Day (2019)

Sports @NHSRCL

Events @NHSRCL

NHSRCL

National High Speed Rail Corporation Ltd.

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